

W_M – Manure weight

N_M – percent Nitrogen content of Manure

N_R – Replacement Fertilizer Nitrogen

N_L – Nitrogen Process Losses

N_B – Nitrogen Baseline

N_{BR} – Nitrogen baseline reduction

N_A – Nitrogen Actual

N_{ARM} – Nitrogen Application Rate Manure

N_{ARF} – Nitrogen Application Rate Fertilizer

EOS – Edge of Stream

DR – Delivery Ratio

RR – Reserve Ratio

NC – Nutrient Credit

A – application acres

Nitrogen Credit Calculation:

Credit Calculation: Credit Calculation is given by

$$NC = (N_B - N_A)$$

Critical in this calculation is the determination of Nitrogen Baseline. Normally, the Baseline is determined by the LA given in the TMDL. While this can be a straight forward exercise when dealing with field specific calculations, it becomes more difficult when dealing with Manure Transport or Treatment. Principally, this due to the fact that we are removing nitrogen from the application stream, and therefore it is difficult to characterize changes in loads as land conditions and the BMPs where the manure hypothetically would have been applied are unknown. This same difficulty applies in estimating the actual Nitrogen discharges.

An approach is to consider the Baseline not as LA given in the TMDL but as a reduction requirement. In the Chesapeake Bay TMDL the following 2010 levels and 2025 targets are given for agriculture:

Nitrogen

2010 = 20 lbs./acre

2025 TMDL-Tracking = 12 lbs./acre

Phosphorus

2010 = 0.8 lbs./acre
2025 TMDL-Tracking = 0.5 lbs./acre

This is equivalent to requiring for agricultural land uses a 40% reduction in 2010 N discharges and a 37.5% reduction for P discharges.

To calculate the baseline load reaching the Bay using the reduction requirement, we assume that manure is applied at an agronomical rate.

$$N_B = W_M \times N_M \times N_{BR} \times EOS \times DR$$

To calculate the actual load, we have to consider where the reduction originates. While manure is removed from the application stream, it will be replaced using chemical fertilizer. The generation of credit is the result of avoiding the application of organic nitrogen which is not available immediately for plant uptake. To estimate the actual N discharge, we first need to calculate the acres upon which manure could have applied in compliance with state regulation for a given crop yield.

$$A = W_M \times N_M / N_{ARM}$$

Next calculate the amount of replacement fertilizer that would be needed to be applied over the same land area assuming the same crop yield.

$$N_R = A \times N_{ARF}$$

The actual load reaching the Bay would be given by:

$$N_A = N_R \times EOS \times DR$$

For Energyworks, we also have to account for the Nitrogen that is lost in the process. So the final expression for credit generation becomes incorporating Pennsylvania's Reserve Ratio

$$NC = (W_M \times N_M \times N_{BR} - N_{ARF} \times W_M \times N_M / N_{ARM}) \times EOS \times DR \times RR - N_L$$

$$NC = [W_M \times N_M (N_{BR} - N_{ARF} / N_{ARM})] \times EOS \times DR \times RR - N_L$$

Example Calculation

Harvest Goal: 175 bu/a of corn grain

Estimating Nitrogen application assuming Manure is applied according to state Law: From the manure management manual (Appendix 1, page 11) for layer manure applied to achieve 175 bu/a corn grain, it is permissible to apply 4 tons manure/A in spring or fall with no incorporation supplemented with 150 lbs of fertilizer. According to data provided by Energy Works, the average N content of its layer manure is 2.836%. The total N for this application of 4 tons/A plus 150 lbs of N fertilizer would be $4 \times 2000 \times 2.836\% = 227 \text{ lbs} + 150 \text{ lbs} = 377 \text{ lbs N / acre}$

Estimating Nitrogen application assuming Chemical Fertilizer: For Chemical Fertilizer, the

recommended N application for corn grain for a harvest goal of 175 bu/a is 190 lbs./acre.
<http://extension.psu.edu/plants/crops/grains/corn/nutrition/nitrogen-fertilization-of-corn>

Applying these factors to the above equation would give:

$W_M \times N_M = 5,965,670$ lbs (taken from Energy Works data and certification)

$N_{BR}=0.6$ (taken from state WIP which assumes a 40% reduction from 2010 Nitrogen levels)

$N_{ARF} / N_{ARM} = 190/377 = 0.504$ (taken from manure management manual, Energy Works Data, and PSU recommendation)

N_L = Based upon air permit limitations this will generally be less than 80 lbs/day at the stack. This needs to be adjusted based upon fate and transport considerations.

$EOS \times DR \times RR = 0.251 \times 0.61 \times 0.9 = 0.216$ (taken from previous certification)

$NC = 123,700 - N_L$

Needed Refinements:

- 1) Verify whether weighted EOS and DR are accurate. Specifically, what assumptions are inherent in the weighted edge of stream.
- 2) Determine fate and transport adjustment factor for stack emission
- 3) Is it possible to use the Bay model/BayFast/NTT directly to calculate loading changes?